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This report investigates store and forward switching services for Group 3 and Group 4 facsimile. The CCITT has defined operational requirements for a store-and-forward facsimile switching service in Recommendation F.162. Customrers can register lists of destinations to which they transmit identical messages, and can then initate transmission to these destinations by input of a single address code. The systems need not necessary transmit a message to the required customers simultaneously. Customers can send the message to many locations by entering the destination address sequentially before transmitting the message. The multi-address facility differs from the Broadcast facility in that it is not necessary to specify destination addresses in advance. Broadcast facility would therefore be used for transmitting multi-destination messages on a regular basis; multi-address facility would be used for occasional multi-destination messages.

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NOVEMBER 1991

OFFICE OF THE MANAGER
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NOVEMBER 1991

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identified, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents and overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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INVESTIGATION OF GROUP 3 AND GROUP 4 STORE AND FORWARD FACSIMILE SWITCHING SERVICE

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1.0 INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc., for the Office of Technology and Standards of the National Communications System, an organization of the U. S. Government, under Task 003 of contract number DCA100-91-C-0031. With the development of equipment that provides store-and-forward facilities for facsimile service, and that permits interoperation between dissimilar facsimile terminals, there is a requirement to ensure that such systems should have the capability of interworking with each other. The purpose of this Task is to investigate store and forward switching services for Group 3 and Group 4 facsimile.

1.1 Background

The CCITT has defined operational requirements for a store-and-forward facsimile switching service in Recommendation F.162. The following list of facilities is relevant to both Group 3 and Group 4 apparatus.

Broadcast transmissions

Customers can register lists of destinations to which they transmit identical messages, and can then initiate transmission to those destinations by input of a single address code. The systems need not necessarily transmit a message to the required customers simultaneously.

Multi-address transmissions

Customers can send the same message to many locations by entering the destination addresses sequentially before transmitting the message. The multi-address facility differs from the broadcast facility in that it is not necessary to specify destination addresses in advance. Broadcast facility would therefore be used for transmitting multi-destination messages on a regular basis; multi-address facility would be used for occasional multi-destination messages.

Abbreviated addressing

Abbreviated address codes can be assigned to frequently called destination numbers, these are, in effect, broadcast lists containing a single entry.

Hold for Delivery requested by the Originator

The node shall enable originators to send documents into the system that shall not be delivered automatically, but shall remain stored in the system. The system shall inform the recipient that the message being sent to him is being held in the facility. The receiving customer can retrieve the message whenever desired by inputting the appropriate request code and identification information.

Hold for Delivery requested by the Recipient

The system shall enable recipients to receive documents from the node that shall not be delivered automatically, but shall remain stored in the system. Before accepting the message from the originator, the system shall inform the originator that a message shall be held for delivery in the node. The receiving customer can retrieve the message when desired by inputting the appropriate request code and identification information.

Deferred delivery by the Recipient

The destination customer has the option of requesting that the delivery of all document be deferred until a specified time, by input of a request code, followed by the required delivery time. Before accepting the message from the originator, the system shall audibly inform him that the message shall be held for delivery in the facility.

Deferred delivery by the Originator

The originator has the option of requesting on a per document basis that the delivery of a document be deferred and take place as close to the date and time specified as possible, but not before, by input of a request code followed by the required delivery time.

Multi-page facility

When transmitting a facsimile document of more than one page during a single session, the initial dialogue between the originating customer and computer establishes the information necessary to link the pages of a multi-page document.

Automatic Reception

The destination node shall recognize the tones generated by terminals capable of unattended automatic reception and, upon recognition of these tones, shall transmit the messages.

Date, Time, and Originator's Identity

The originating node shall include reference information on all documents. This information shall include date, time and calling terminal identification. Called terminal identification may be prepared as an option.

Recall attempts

If a destination terminal is busy, it shall be recalled at a certain interval up to some maximum period. When it is impossible for a destination terminal to receive messages due to the absence of recording paper, lack of power supply or the terminal being out of order, nondelivery advice shall be sent to the originator after the confirmation of this situation.

Closed User Group

Exchange of communication is limited to a group of terminals designated by a subscriber and no calls into or out of the closed user group are permitted.

Information Retrieval

Information may be stored in a node in advance which can be retrieved by any customers through dialing the appropriate number. Such information could be weather reports, stock market quotes, etc.

1.2 Objectives

There are four main objectives:

1. For Group 3 facsimile, investigate the protocol modifications necessary (if any) to support store-and-forward capabilities. For Group 3 terminals, the protocols defined in Recommendation T.30 do not include any of the facilities described above. This report reviews the applicable protocols and determines what modifications, if any, need to be made to the Recommendations to support these features.
2. For Group 4 facsimile, investigate how Group 4 might access store-and-forward systems. Message Handling System (MHS) access procedures currently are being defined in the CCITT X.400 series of Recommendations. This report investigates the application of these procedures together with potential alternative procedures for Group 4 terminals operating both on the PSTN and the PSDN in the store-and-forward mode.
3. Recommend terminal modifications, if any, to support these capabilities. For example, how shall the user enter the destination address, and how shall this information be communicated to the node. Consideration is given to the problem of retrofitting existing Group 3 and Group 4 terminals.
4. Recommend conversion rules to permit Group 3 terminals to send messages to Group 4 and vice versa, and from character oriented terminals to facsimile terminals.

1.3 Report Organization

Section 2.0, "*Message Handling Systems*," discusses store and forward systems Group 3 and Group 4 facsimile might use.

Section 3.0, "*Facsimile and Store-and-Forward Systems*," discusses the current state of Group 3 and Group 4, the difficulties of supporting Group 3 and Group 4 on a store-and-forward system, the capabilities store-and-forward systems might provide Group 3 and Group 4, and how to possibly integrate facsimile and store-and-forward systems.

Section 4.0, "*Terminal Modifications*," discusses methods for providing Group 3 and Group 4 terminals access to store-and-forward systems.

Section 5.0, "*Conversion Rules*," discusses converting facsimiles to other document types, like text, and vice versa.

Section 6.0, "*Recommendations*," recommends how to provide Group 3 and Group 4 facsimile with store-and-forward capabilities.

Section 7.0, "*Areas for Future Study*," suggests areas of additional investigation.

2.0 Message Handling Systems

There are many ways to deliver packages and information to their proper destinations, and historically these deliveries were mainly done by postal mail and courier services. Today, for information transfers, electronic mailing and delivery is an economic and speedy substitute.

Electronic mail fits into a continuum of communications media, including the telephone, physical mail delivery systems, and broadcast media like radio and television. Each medium has advantages and disadvantages. Electronic mail is closely associated with the telephone and physical mail systems, sharing features of both. Electronic mail has several advantages:

- Electronic mail is faster than mail services. Electronic mail's most obvious benefit is that it reduces the communications cycle in comparison to physical mail services.
- Electronic mail increases productivity. By compressing delays associated with document deliveries, shorting the duration of a task is possible.
- Multiple addressing is possible.
- Messages may be stored in a MHS for later retrieval.
- It is possible to convert the document to a format acceptable to the receiving terminal.

Electronic mail also has disadvantages:

- Communications are usually not real-time.
- Messages might be lost.
- Dependency upon the electronic mail vendor to guarantee privacy of messages.

Electronic mail comes in many guises.[1],[2] A few are teletype, telex, telephone, television, facsimile, and computer-based mail systems. The last one, computer-based mail systems (CBMS), is of particular importance because its flexibility makes it possible to interconnect the different types of electronic mail terminal equipments (for example, Personal Computers (PCs) to facsimile equipments), and to effectively manage the information transfers

at economic prices. Currently, CBMSs dominate the electronic mail arena to such an extent that their service is what people think of when the term "electronic mail" is used.

Nevertheless, facsimile transfers could be considered the true form of electronic mail: an exact copy of a document is sent electronically, usually over the Public Switched Telephone Network (PSTN), to a destination where it is typically reproduced on paper. This process mimics the postal delivery system where a document is physically moved from a sending location to a defined destination. The primary difference is that, with fax, the copy of the document arrives much faster than when the original is sent by postal mail or by a courier service (seconds instead of days).

CBMSs do have a potential neither fax or postal mail or courier systems or any of the other types of electronic mail systems have. That is, the ability to interconnect and manage all the different types of electronic mail. For example, CBMSs have the potential to eventually allow the transcribing of voice mail (telephonic messages) onto paper, or the transforming of text-based mail into voice mail.

To provide a common set of standards the International Telegraph and Telephone Consultative Committee (CCITT) is defining a set of Recommendations concerning Message Handling Systems (MHS). They are, however, incomplete. With regards to fax, they do not, as yet, describe how facsimile equipments will access, use, and work on computer-based MHSs. Although much work remains (concerning fax and other communication systems), the MHS Recommendations do have sufficient detail to allow CBMS manufacturers to make interoperable systems.

2.1 CCITT MHS

The CCITT is evolving application *independent* MHS through their X.400 series of Recommendations. (CCITT standardized MHS applications are the InterPersonal Messaging (IPM) service and the Store and Forward Facsimile (COMFAX) service. See Sections 2.2 and 2.3.) An MHS's primary purpose is to allow users to exchange messages on a store-and-forward basis. In store-and-forward systems, the sender connects to the system and sends a message. The system assumes responsibility for delivery and may store the message in a message repository. Message deliveries may occur immediately or be postponed to a later time.

Meanwhile, the sender can either send additional messages, view received messages, or disconnect.

Storing the message in the system makes it possible to offer facilities which were previously impractical. For example, multiple addressing (sending the same message to a number of addresses), group-addressing (sending the same message to a defined address list), and delayed sending (sending a message at a pre-set time; for example, to take advantage of overnight tariffs), are possible with a store-and-forward system but impracticable with postal mail services.

Within an MHS, messages are the units of information to be conveyed by the system. They are viewed as consisting of envelopes and contents. The envelope is addressed with the information which is needed by the system to correctly handle the message. At a minimum, it contains the recipient's address. The contents of the message are, at least in principle, invisible to the mail system, and may contain all types of electronic information (fax, text, graphics, voice, etc.). Although an MHS usually ignores the contents, it may convert them to a form compatible with a recipient's terminal equipment, if it must do so for proper delivery.

The CCITT's MHS consists of the following components (See Figure 2-1):

Users	Humans, or computer processes
Access Unit (AU)	Allows users to connect to the MHS using other communication systems
User Agent (UA))	Submits or receives messages on behalf of a single user (individual or other system)
Message Transfer Agents (MTA)	Convey messages to intended recipients
Message Store (MS)	Message repository; optional intermediary between a user agent and a message transfer agent; stores and permits retrieval of delivered messages
Message Transfer System (MTS)	Collection of message transfer agents; delivers messages to user

agents, access units, or message stores, and can return notifications to the sender

Physical Delivery Access Unit (PDAU) . Physical delivery (postal mail, etc.) of messages for users connected through access units

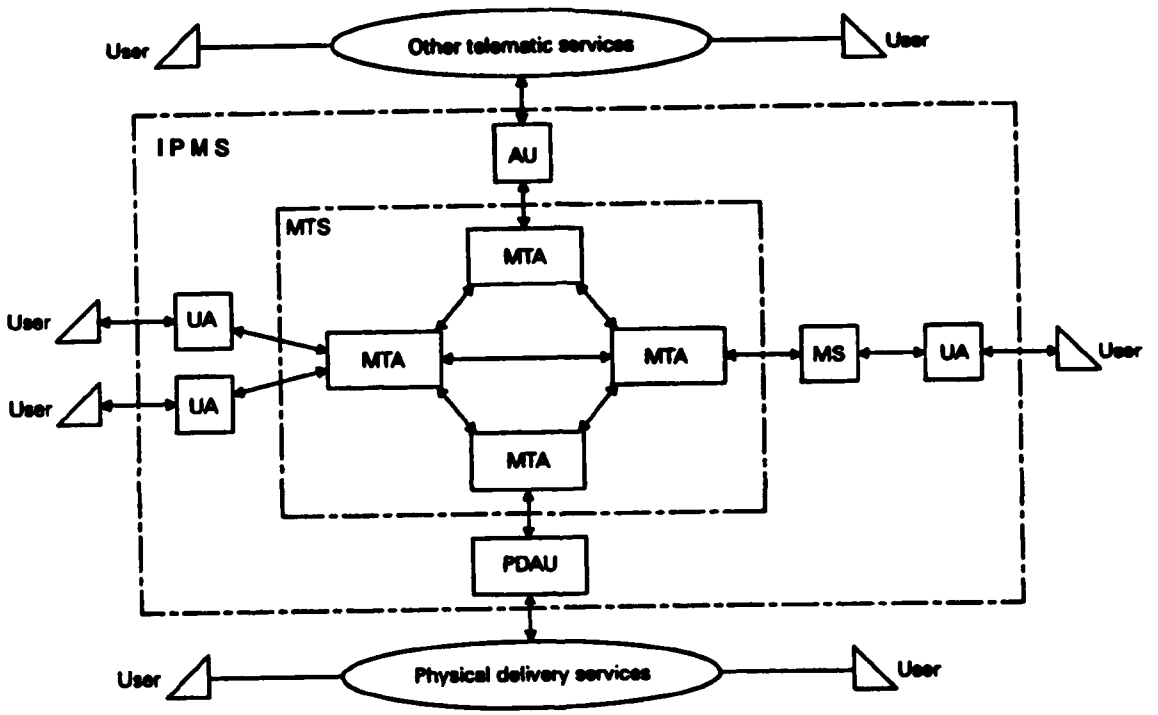

Figure 2-1. MHS Functional Model

Users can be either originators (when sending a message) or recipients (when receiving a message), and access the MHS through a User Agent.

User Agents are application processes which help users prepare messages and are normally incorporated in the user's terminal or in a centralized system which serves a group of users. The User Agent interacts either with a Message Store or directly with the Message Transfer System to submit and receive messages to and from the Message Transfer System.

The Message Store is optional and is mainly used by User Agents and the Message Transfer System. User Agents may use the Message Store to save delivered messages for later retrieval, or to save messages for later submission to the MTS, or both. The Message Transfer System may use the Message Store if it is unable to deliver a message.

Delivery of messages is the responsibility of the Message Transfer System which often consists of a number of Message Transfer Agents. The Message Transfer Agents are, generally speaking, the processing systems (like CBMSs) which allow porting of messages from one location to another. In addition, User Agents and Message Stores can either be co-resident in the same processing system with a Message Transfer Agent or in processing systems separate from the Message Transfer Agent's processing system.

When other services, like fax, would like to connect to the Message Transfer System, they interoperate with the MTS via Access Units. Access Units are specially designed to interact with these services and smooth the transfer of messages from the accessing services to the MHS and vice versa. At present, the fax AU definitions are incomplete and are under study by the CCITT.

An MHS, according to the CCITT, can be constructed using any network fitting in the scope of the reference model of open systems interconnection (OSI reference model). OSI is the work of the International Organization for Standardization (ISO), whose primary goal is the blind interchange of information between different systems, with a secondary goal of retaining existing standards whenever possible.[3],[4]

OSI consists of a seven-layer model or framework which ensures that all new communication standards are compatible. Secondly, a system obeying the OSI model in its communication with other systems is termed an "open system". The OSI open systems concept allows application processes such as MHS to interact with any other application process anywhere in the world.

The seven layers of the OSI model are divided among three different functions: user interaction, interface, and communication network interaction (See Figure 2-2).

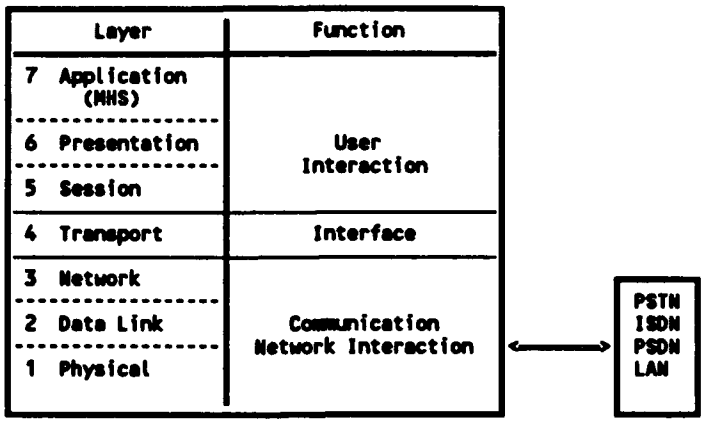

Figure 2-2. The OSI Model

The seven layers have the following definitions:

Application	-	The highest level. It is the user interface between an MHS or other services and the OSI environment.
Presentation	-	The presentation layer deals with issues of how the information is presented to both the sender and receiver. It preserves the meaning of data while resolving syntax differences.
Session	-	The session layer establishes, manages, and releases the communication connection.
Transport	-	Acts as a consistent interface between the application-related functions and the transmission-related functions.
Network	-	Provides routing and relaying through switched telecommunication media.
Data Link	-	Reliably transfers all information over the physical transmission media.
Physical	-	Deals with the transmission of a bit stream, regardless of its meaning, across a physical communication medium.

At present, the CCITT has defined at least two services based upon the MHS model: the Message Transfer Service (MT service), and the Interpersonal Message Service (IPM service). The MT service provides the general application independent, store-and-forward message transfer service. The IPM service is tailored for ordinary interpersonal business or

private correspondence and provides a user with features to assist in communicating with other IPM service users. In doing so, it uses the capabilities of the MT service for sending and receiving the interpersonal messages. The Store and Forward Facsimile (COMFAX) service takes advantage of IPM facilities to transfer facsimiles between fax terminals and IPM users.

2.2 InterPersonal Messaging (IPM) Service

The intention of the IPM service is to enable users to send interpersonal messages to one or more recipients, either using User Agents or access units to the telex or telematic services. Accessing teletex, telex, facsimile and physical delivery services is optional. At present, the CCITT is working on a Recommendation that specifies how the IPM service can deliver facsimile messages from an IPM user to a facsimile terminal using T.30 for call establishment and delivery.[5] The optional physical delivery access unit allows IPM users to send messages to users outside the IPM service who have no access to the IPM. Furthermore, the message store may optionally be used by IPM users to take delivery of messages on their behalf.

2.3 COMFAX

Although MHS now symbolizes the epitomy of possible future communication capabilities, it is still in its infancy. Between now, when services are now largely independent, and then, when services can interoperate, growth within a particular service should still be accommodated. For example, given the current popularity of Group 3 fax and the desire of some of its users to have a few MHS-like capabilities (like multiple addressing), a standard should exist to accommodate these users.

COMFAX is the result of the CCITT's realization that facsimile communications have advanced beyond point-to-point image transfers, and now incorporate services like store-and-forward. COMFAX is a store-and-forward service whose general requirements are defined in the CCITT's Recommendation F.162, "*Service and Operational Requirements of Store-and-forward Facsimile Service (COMFAX).*" How to meet those requirements, however, needs defining. The generally accepted view of COMFAX sees COMFAX as using IPMS facilities to transfer facsimiles between fax terminals, and between fax terminals and IPM users.

3.0 Facsimile and Store-and-Forward Systems

Most facsimile equipments (Group 3 and Group 4) are currently designed to work in point-to-point connections where the sending and receiving terminals talk on a real-time basis. MHS, on the other hand, is designed for multipoint connections where sending and receiving terminals talk indirectly, and where messages may be stored in the network until the recipient has the time (or inclination) to retrieve them. This poses a problem for facsimile equipments. Having direct negotiations between sending and receiving equipments is not necessarily possible, and if several terminals are to receive the same message, establishing common capabilities could prove difficult. One way for a sender to ascertain the deliverability of a message is to send a probe to all intended recipients. Probes, on an MHS, are usually treated just like messages (except there is no message to deliver) and can determine if a message is deliverable.

3.1 Facsimile Issues Relevant to Store-and-Forward

The CCITT facsimile recommendations allow facsimile terminals to have both basic and optional capabilities. For example, a basic capability that all Group 3 terminals must have is a resolution of 98x204 pels/inch. A resolution of 196x204 pels/inch is optional. When the terminals communicate they must usually establish common optional capabilities. This may not be possible on a MHS. Nevertheless, a review of some of the optional capabilities might suggest how MHSs can support them. Optional capabilities include the following:

1. Image Compression Techniques
2. Transmission Rates
3. Resolutions
4. Binary File Transfer (BFT)
5. Secure Fax

3.1.1 Image Compression Techniques

Group 3 and Group 4 facsimile terminals now respectively adhere to compression techniques described in CCITT Recommendations T.4 and T.6. The use of T.6 was, however, recently approved by the CCITT for use by Group 3 as an option. Furthermore, other compression techniques are being studied for compressing bi-level, gray scale, and color imagery by Group 3 and Group 4 terminals. These algorithms come from the Joint Bi-Level Experts Group (JBIG) and the Joint Photographic Experts Group (JPEG). JPEG was formed at the end of 1986 under the umbrella of the ISO working group (now ISO/IEC/JTC1/SC2/WG10 - Photographic Image Coding). It brings together ISO picture coding knowledge and CCITT telecommunications service expertise (from the New Image Communications (NIC) group of CCITT Study Group VIII). Its aim is to select and develop compression/decompression techniques for natural color and gray scale images. JBIG is a related working group devoted to bi-level (binary or black and white, no gray scale) images. To properly decompress an image, the receiver must use an appropriate decompression technique.

3.1.2 Transmission Rates

Typically, Group 3 specifies operation over the PSTN, in real time, at rates of 2400, 4800, 7200, 9600, and 14400 b/s. Whereas, Group 4 specifies operation over digital networks at rates up to 64 kb/s. If a MHS has neither message store or automatic rate adaption capabilities, attempting to connect terminals with different transmission rate capabilities could result in a loss of information.

3.1.3 Resolutions

Facsimile terminals may use several different resolutions. For example, Group 3 provides 98x204 and 196x204 pels/inch resolution, and will soon offer 300 and 400 square pel/inch resolution. Similarly, Group 4 offers 200, 240, 300, and 400 square pel/inch resolution. If there is a resolution mismatch between sending and receiving terminals, receivers could have difficulty reproducing the facsimile.

3.1.4 Binary File Transfer (BFT)

Binary file transfer (BFT) allows for the transmission of binary files by facsimile terminals. The CCITT is considering including BFT in Group 3 as an option. BFT is highly desirable for equipments and other systems that handle both facsimile transmissions and binary file transfers. (e.g., personal computers and work stations that use add-in fax boards.)

3.1.5 Secure Fax

Most facsimile transmissions currently provide little or no security. There are no guarantees that a message was delivered to the intended recipient nor that no eavesdropping took place. For fax, these issues are not currently being addressed by CCITT Recommendations, although commercial concerns are becoming interested. The Department of Defense has, however, issued a standard, MIL-STD-188-161B, which does stipulate how to securely transmit facsimiles. On some MHSs, both types of security are available. For example, to ensure the proper recipient receives his messages, the messages can be stored in a message store until the recipient requests them. To request them, the recipient must provide identification (e.g., passwords) proving that he is the correct recipient.

The CCITT is planning to offer limited security for a new Group 3 polling mode. An optional password is included with a new selective poll. If the password is invalid the call is terminated by the called terminal. The selective poll permits the calling terminal to elicit a specific document from the called terminal. Both of these capabilities are planned for inclusion into the T.30 Recommendation and approval to do so is being sought under the CCITT's resolution 2 procedures.

3.2 Supporting Facsimile on Store-and-Forward Systems

Most facsimile terminals are designed to work in point-to-point environments on a real-time basis. Whereas, most MHSs provide multipoint services coupled with delayed deliveries. For most facsimile terminals, a multipoint, delayed delivery environment poses difficulties. For example, establishing common capabilities might be difficult for some facsimile terminals in a multipoint environment. If an MHS provides sufficient conversion capabilities, however, few

of the facsimile capabilities actually require real-time negotiation. Ones that might are non-standard facilities and polling. All others, data signalling rates, resolution, compression techniques, tonal ranges (bi-level, gray scale, color), etc., are processable by MHSs having appropriate conversion capabilities. For example, if a sending terminal has a different resolution capability than a receiving terminal, then an MHS with a resolution conversion facility could perform any necessary resolution conversions prior to delivering the facsimile message. Similarly, conversions can be performed for coding techniques, tonal ranges, etc. Automatic rate adaptations are, in general, performed naturally by MHSs and account for any differences in data signalling rates. Depending on the conversion, however, it is possible some loss of information may occur.

Non-standard facilities and polling require special attention. Non-standard facilities allow facsimile manufacturers to distinguish their equipment from other manufacturers' by permitting the inclusion of unique capabilities. Polling mandates that the called terminal will become the sending terminal (opposite of normal operation). Normally only the recipient's terminal can provide the information needed to determine if these functions can be performed. Polling is probably the most difficult to do if capabilities are not exchangeable; it is a procedural operation that requires a prompt response. Non-standard facilities could possibly be registered for later recall for each facsimile terminal known to a MHS. Doing so assumes that using the NSF doesn't precipitate an escape to non-standard procedures, or non-standard modulation schemes, and that the MHS can provide terminal registration capabilities).

3.2.1 Registering Facsimile Terminal Capabilities

Registering facsimile terminal capabilities with a MHS enables fax equipments to use almost all their capabilities on that MHS, can provide message security, and can help reduce an MHS's workload. In one approach, the capabilities registered for a terminal could be associated with the terminal's owner's MHS address. Doing so allows an MHS to provide an originator's terminal with a recipient's terminal's capabilities on a real-time basis. This has several advantages:

- Non-standard facilities capabilities become known
- Conversions by the MHS can be reduced or eliminated
- Data signalling rates are more closely matched

- The MHS can store the message until the recipient requests it, if a message store is available
- Authentication of the recipient is possible

By registering non-standard facilities capabilities, sending terminals can determine the capabilities of receiving terminals. Secondly, knowing resolutions, coding techniques, etc., allows both terminals to match capabilities without necessarily using the MHS for conversions, and thereby reduces the MHS workload. Also, by more closely matching data signalling rates and if both equipments are on-line, data buffering by the MHS can be reduced. If more than two equipments are involved, as would be the case with multi-addressing, then using the MHS to perform conversions and buffer data might be necessary especially if recipient terminals have differing capabilities and differing signalling rates. Receipt authentication is made possible. This could take the form of a delivery on request, where the MHS stores the message until a recipient requests it. At that time, the MHS might require authentication that the recipient is the intended recipient.

3.2.2 Polling

Polling operations where the calling terminal instructs the called terminal to send any documents in its hopper can be implemented on MHSs, but with modification. Given that on most MHSs it is impractical to expect a called terminal to respond to a calling terminal on a real-time basis, polling as now performed by facsimile terminals (Group 3, for example) would be difficult to implement. A polling terminal expects the called terminal to *immediately* begin transmission of any documents in its hopper; an operation which may be impossible on a MHS: the called terminal may be unattached, the called terminal may be busy, the MHS communication delays may be too long, and so forth.

Nevertheless, "polling" could be accomplished if the MHS assumes responsibility for conducting the poll. During a poll the MHS could intercede and tell the polling terminal that there are no documents available from the polled terminal (even if there are). Simultaneously, the MHS would poll the intended recipient's terminal and would receive any polled documents on behalf of the polling terminal. 'These documents would then be sent to the formerly polling terminal as though the polled terminal initiated the transmittal process.

Although this approach is feasible, it does have at least two disadvantages: 1) the formerly polling terminal could have difficulty identifying and separating the polled documents from normally received traffic, and 2) the time of the poll may have significance. To simplify identification, the MHS could mark polled documents, and could time deliveries such that the first document polled is the first document delivered. If the time of the poll is significant, the MHS could speed up transmittal.

3.3 Providing Fax with Store-and-Forward Capabilities

If the InterPersonal Messaging System (IPMS) can support fax, it would also be beneficial if fax could take advantage of some of the MHS capabilities. These capabilities, for COMFAX and for the CCITT's IPMS, fall into five main service categories: distribution, delivery, security, reporting, and message store.

3.3.1 Distribution Services

Historically, fax has been a point-to-point service where document distributions have typically been to just one recipient. With MHSs, however, distributions can be to many recipients (multipoint). For COMFAX, these distributions can be on a *multi-address* or *broadcast* basis where multi-address distributions are for occasional multiple recipient distributions, and where broadcast distributions are for frequent multiple recipient distributions. With multi-address distributions, the originator sends the same message to many recipients by entering the destination addresses sequentially before sending the message. Whereas for broadcast distributions the originator registers a list of addresses with the COMFAX service to which identical messages are regularly transmitted. Then, prior to transmitting a message, the originator merely specifies the list to use for distributing the message. Two other distribution services offered by COMFAX are abbreviated addressing and closed user group. Abbreviated addressing allows users to assign abbreviated address codes to frequently called recipients. These are, in effect, broadcast lists containing a single entry. A closed user group restricts communication to a group of terminals as designated by a subscriber. No calls into or out of the group are permitted. A desirable variation on addressing is secondary addressing, that is, in effect, the automatic calling of extensions. IPMS supports similar services. For example, in IPMS, lists of addresses, called distribution lists (DLs), can be used to specify where a

document is to be sent. For Group 3 facsimile, the CCITT is seeking approval of a subaddressing capability to be added to T.30 under resolution 2 procedures.

3.3.2 Delivery Services

In IPMS, delivery services may extend beyond the simple conveyance of messages to include capabilities ranging from postmarks to message conversions. Altogether there are at least six different delivery service categories to which a particular service might belong:

postmarks	Allow the originator, MTS, and recipient to receive timestamp indicators showing the time of message submission, receipt, etc., along with MHS-assigned labels which simplify message tracking within the IPMS.
conversions	Allow or inhibit conversions, perform conversions either explicitly or implicitly, and indicate if conversions have been performed.
delivery holds and restrictions	Control the timing of deliveries and their cancellation (if any), and the ability of users to receive messages.
delivery priority	Control the priority of deliveries (i.e. urgent, non-urgent, normal)
delivery inquiries	Allow probes to check if a message is deliverable.
delivery method	Specify method of delivery (e.g. physical mail, telex, etc.)

The IPMS services belonging to each of these categories are described in Table 3-1.

COMFAX has six delivery related services:

1. Hold for delivery (requested by originator or recipient)
2. Deferred delivery (requested by originator or recipient)
3. Multipage
4. Automatic reception

Table 3-1. Categorized Delivery Services

Category and Service	Description
Postmarks	
- Delivery time stamp indication	- MTS provides recipient UA with date and time of message delivery
- Message identification	- MTS provides UA with unique identifier for each message
- Submission time stamp indication	- MTS provides recipient and originator UA with date and time of message submission
Conversions	
- Content type indication	- Originating UA indicates content type of submitted message
- Conversion prohibition	- Originating UA specifies that implicit encoded information conversions should not be performed on a particular message
- Conversion prohibition in case of loss of information	- Originating UA specifies that encoded information conversions should not be performed if information will be lost
- Converted indication	- MTS informs recipient UA of any conversions performed on encoded messages
- Explicit conversion	- Allows originating UA to request the MTS to perform a specific conversion
- Implicit conversion	- Allows recipient UA to request the MTS to perform any necessary conversion on messages prior to delivery
- Original encode information types indication	- Allows an originating UA to tell the MTS what the encoded information type is of a message being submitted
Delivery holds and restrictions	
- Deferred delivery	- Originating UA may specify that a message should be delivered on or after a particular date and time
- Deferred delivery cancellation	- Allows originating UA to cancel a deferred message delivery
- Hold for delivery	- Recipient UA may ask that all its messages be held for later delivery
- Latest delivery designation	- Originating UA may specify latest time a message may be delivered
- Users capabilities registration	- Allows a UA to register the content type, size, and coding of messages delivered to it
Delivery priority	
- Grade of delivery selection	- Allows the originating UA to specify that a transfer is either urgent, normal, or non-urgent
Delivery inquiries	
- Probe	- Allows a UA to determine if a message can be delivered
Delivery method	
- Requested delivery method	- Allows a user to request, on a per-recipient basis, the preference of method for message delivery

5. Recall attempts
6. Interrupted message recovery

The first two are like the services offered by IPMS with the exception that either the originator or recipient may request them. The multipage facility links the pages of a multipage document and identifies where page breaks should occur. Automatic reception requires that recipient terminals must be capable of unattended automatic reception; manual reception would

lead to operational and technical difficulties. Recall attempts specifies that a busy terminal must be recalled periodically before reporting a non-delivery advice. And, interrupted message recovery specifies that if a delivery is interrupted, it should resume as soon as possible starting with the first unsuccessfully delivered page. Plus, the recipient should be given sufficient information to correlate the different parts of the interrupted message.

3.3.3 Security Capabilities

IPMS supports numerous security services ranging from proof-of-delivery to message encryption. These services belong to seven different categories:

Origin authentication	Gives users the ability to authenticate messages, probes, and reports, and their delivery.
Secure access management	Provides protection for resources against their unauthorized use.
Data confidentiality	Protect data against unauthorized disclosure.
Data integrity	Counters active threats to the MHS.
Non-repudiation	Provides irrevocable proof that the submitting, sending, or delivery of a message did occur as claimed.
Message security labelling	Associates labels with all entities in the MHS, and allows policies to be implemented that define which parts of the MHS may handle messages with specific security labels.
Security management . . .	Allows users to register and change credentials and security labels.

The IPM services belonging to each of the categories are shown in Table 3-2.

COMFAX requires the marking of all documents with the date, time, and originator's identity. The date and time stamp must show when the COMFAX service completely received the documents from the originating terminal. Plus, when users access COMFAX, they should enter a User Identity (ID) Code and Personal Identity Number (PIN) to ensure security of use.

Table 3-2. Categorized Delivery Services

Category and Service	Description
Origin authentication	
- Message origin authentication	- Provides means to authenticate to a recipient or MTA where a message came from (e.g. a signature)
- Probe origin authentication	- Provides means to authenticate to a MTA where a probe came from
- Report origin authentication	- Provides means to authenticate where a report came from
- Proof of submission	- Provides authentication to the originator from the MTS that a message was submitted for delivery to the intended recipient
- Proof of delivery	- Provides authentication to the originator of the identity of the recipient(s) and the delivered message and content
Secure access management	
- Peer entity authentication	- Confirms the identity of the connecting entity, and provides confidence that an entity is not attempting a masquerade or an unauthorized replay of a previous connection
- Security context	- Limits the scope of passage of messages between entities by referencing a message's security label
Data confidentiality	
- Connection confidentiality	- Not explicitly provided
- Content confidentiality	- Ensures that a message's content is known only to the originator and recipient
- Message flow confidentiality	- Protects information which might be derived by message flow; MHS provides limited protection in form of double-envelope techniques
Data integrity	
- Connection integrity	- MHS does not provide an explicit connection integrity security service
- Content integrity	- Allows recipients to verify that their messages were received unmodified
- Message sequence integrity	- Allows recipients to verify that their messages were received without message loss, re-ordering, or replay
Non-repudiation	
- Non-repudiation of origin	- Provides recipient with irrevocable proof of the origin of a message
- Non-repudiation of submission	- Provides originator with irrevocable proof that a message was submitted for delivery
- Non-repudiation of delivery	- Provides originator with irrevocable proof that a message was delivered to a recipient
Message security labelling	
- Message security labelling	- Allows originator to indicate sensitivity of a message to permit proper handling by the MTS and the recipient
Security management	
- Change credentials	- Permits the credentials of a MTS-user or a MTA to be updated
- Register	- Permits registering of a user's permissible security labels
- MS-register	- Permits registering of a user's permissible security labels with a MS

3.3.4 Reporting Capabilities

Reports are generated by the IPMS's MTS and relate to users the outcome or progress of a message's or probe's transmittal to one or more recipients. There are two types of reports: a delivery report and a non-delivery report. Delivery reports relate the delivery, export, or affirmation of a subject message or probe, or DL expansion. Non-delivery reports relate the non-delivery or non-affirmation of subject messages or probes. A delivery means the message has been conveyed to the recipient, but does not mean he has actually received it. For example, the IPMS might place the message in the recipient's message store. Thus, a user may also request a notification of receipt or non-receipt of a message by a recipient. These reports are requested by an originator and are generated as a result of some recipient action (such as reading or not reading the message).

COMFAX offers four reports: a non-delivery advice, a delivery confirmation, a non-receipt advice, and a receipt advice. Non-delivery advices occur if a message is undeliverable to a recipient address. Non-receipt advices occur if a message is undeliverable to a destination facsimile terminal. Delivery confirmation and receipt confirmation are sent only when requested. Currently, the CCITT is debating whether non-receipt advices should be sent if the destination terminal is busy or out of order in spite of recall.

3.3.5 Message Store Services

IPMS offers six basic message store services:

Stored message alert	User alert generated when a message arrives which meets a registered set of criteria.
Stored message auto-forward .	User may specify that selected messages which meet registered criteria are to be forwarded to other users and DLs.
Stored message deletion	Recipient may delete messages from the MS service.
Stored message fetching	Allows a recipient to retrieve part or all of a message from a MS.

Stored message listing . . . . . Provides a recipient with information about messages stored in the MS.

Stored message summary . . . Provides a recipient with a count of the number of messages meeting certain criteria.

These services can only be offered if the UA connects to a MS.

COMFAX offers message store capabilities within its store-and-forward units fax (SFU), and specifies a maximum message size of 128 pages or 5 Megabytes of data content.

3.3.6 Summary of Capabilities

Table 3-3 shows a summary of the IPMS services, and Table 3-4 shows a summary of the COMFAX services. Please note that there is some overlap (see marking of certain COMFAX services).

3.3.7 Commercial Store-and-Forward Facsimile Services

There are commercial vendors (At&T and MCI, for example) who already supply store-and-forward facsimile services. In general, their services are built upon the CCITT's X.400 series MHS concepts. For example, the following capabilities are offered:

- Broadcasting and multi-addressing transmissions
- Deferred delivery
- Broadcast cancellation (when the broadcast should end)
- Retry capability (for busy or non-answering recipients)
- Distribution lists
- Abbreviated addressing
- Non-delivery notifications
- Summary reports (describes delivered, pending, and canceled messages)
- Inquiry reports (describes status of all messages submitted)
- Exception reports (Shows number of messages delivered and explains why undelivered messages were undelivered.)

Table 3-3. Summary of MHS Services

Service	Distribution	Delivery	Security	Reports	Message Store
Access management					
Alternate recipient allowed	x				
Alternate recipient assignment	x				
Content confidentiality			x		
Content integrity			x		
Content type indication		x			
Conversion prohibition		x			
Conversion prohibition in case of loss of information		x			
Converted indication		x			
Deferred delivery		x			
Deferred delivery cancellation		x			
Delivery notification				x	
Delivery time stamp indication		x			
Designation of recipient by directory name	x				
Disclosure of other recipients	x				
DL expansion history indication	x				
DL expansion prohibition	x				
Explicit conversion		x			
Grade of delivery selection		x			
Hold for delivery		x			
Implicit conversion		x			
Latest delivery designation		x			
Message flow confidentiality			x		
Message identification		x			
Message origin authentication			x		
Message security labelling			x		
Message sequence integrity			x		
Multi-destination delivery	x				
Non-delivery notification				x	
Non-repudiation of delivery			x		
Non-repudiation of origin			x		
Non-repudiation of submission			x		
Original encoded information types indication		x			
Originator requested alternate recipient	x				
Prevention of non-delivery notification				x	
Probe		x			
Probe origin authentication			x		
Proof of delivery			x		
Proof of submission			x		
Redirection disallowed by originator	x				
Redirection of incoming messages	x				
Report origin authentication			x		
Requested delivery method		x			
Restricted delivery	x				
Return of content			x		
Secure access management					
Stored message alert					x
Stored message auto-forward					x
Stored message deletion					x
Stored message fetching					x
Stored message listing					x
Stored message summary					x
Submission time stamp indication		x			
Use of distribution list	x				
User/UA capabilities registration		x			

Table 3-4. Summary of COMFAX Services

Service	Distribution	Delivery	Security	Reports	Message Store
Abbreviated addressing†	x				
Automatic reception		x			
Broadcast†	x				
Closed user group†	x				
Database query					x
Database submission					x
Date, time, and originator's identity†			x		
Deferred delivery by originator†		x			
Deferred delivery by recipient		x			
Delivery confirmation†				x	
Hold for delivery requested by originator†		x			
Hold for delivery requested by recipient†		x			
Information retrieval					x
Multiaddress†	x				
Multipage facility		x			
Non-delivery advice†				x	
Recall Attempts		x			

† Similar services offered by MHS

- Handles Group 3 and Group 4
- Security features (ID codes, user IDs, passwords, calling restrictions)
- Receives and distributes messages from telex, data terminals, and office automation systems to fax, telex, cablegram or electronic mail addresses.
- Message stores
- Physical delivery

Although commercial vendors provide a large portion of COMFAX and IPMS capabilities, there are areas needing improvement. For example, most commercial vendors do not permit facsimile equipments that have nonstandard capabilities to use those capabilities. Nor do they necessarily permit a facsimile equipment to poll other facsimile equipments.

3.4 Modifying the Facsimile and Store-and-Forward Services

3.4.1 Store-and-Forward System Modifications

Although most of the modifications to make fax work on IPMS or COMFAX can be made to the facsimile recommendations, at least one modification should be made to IPMS and

COMFAX: registering terminal capabilities. Registering terminal capabilities with a store-and-forward system allows the terminal equipments to fully participate. In particular, equipments using the non-standard facilities will be able to interact. Nevertheless, for Group 3, it does not help with non-standard modulation schemes.

3.4.2 Group 3 Fax Modifications

The mechanisms incorporated into Group 3 Fax (Recommendation T.30) to support IPMS and COMFAX should probably be constrained in two directions. First, the mechanisms should interface with the embedded base of Group 3 equipments. Second, any mechanisms to support higher-level services should be consistent with existing standards for these services. For example, COMFAX is the first step in allowing the extension of message handling to the facsimile world, so the mechanisms should be consistent with the COMFAX (and IPMS) Recommendations.

Certain high-level requirements arise from the use of these two constraints, and they are divisible into short-term and long-term categories.[6] Short-term requirements would support limited functionality with no T.30 protocol changes; long-term requirements would maximize functionality but require T.30 modifications.

The short-term requirements might be as follows:

- Compatible with the existing T.30 protocol
- Ability to use the embedded base of Group 3 machines to originate a request or to receive a response (although not necessarily to process the request or to return a response).
- Use a widely available signaling capability
- Minimize the cost of an implementation

The long-term requirements might be as follows:

- Extend feature transparency to the terminal level so store-and-forward and database capabilities can be invoked locally.
- Provide evolutionary path for including additional capabilities in the facsimile terminal
- Compatible with IPMS
- Compatible with database standards for database submission and retrieval

In addition, to deal with these two constraints and to meet the short and long-term requirements, two mechanisms could be used: one to meet a limited set of services in the short term within the present T.30 protocol, and another to meet the complete set of services in the long term. The short term mechanism would allow the T.30 protocol to remain unchanged; thereby allowing communication with the embedded base of Group 3 machines. The long-term mechanism would allow changes to the T.30 protocol, and might rely on the construction of an envelope in the case of store-and-forward transfer.

The services supported by the short and long-term mechanisms could be classified as mandatory or optional (See Table 3-5 and Table 3-6). Two important areas that are critical to the COMFAX service are terminal identification and secondary addressing. Neither are included in the current versions of T.30.

A means of terminal identification is necessary to allow the answering machine to quickly decide what the calling machine is, especially with the many types of modems now being used on the PSTN. Secondary addressing allows the facsimile message to be routed automatically to its final destination. For instance, if there is one fax call number, but many extensions, and each extension is connected to a different facsimile machine.

3.4.3 Modify Group 4 Terminals

Like Group 3, Group 4 was not intended to interface with store-and-forward systems, and like Group 3 two mechanisms could be used: one long-term and one short-term. The short-term mechanism would emphasize maximizing IPMS functionality without requiring protocol

Table 3-5. Group 3 MHS Service Requirements

Service	Short Term	Long Term
Access management		
Alternate recipient allowed	O	O
Alternate recipient assignment	O	O
Content confidentiality	O	O
Content integrity	O	O
Content type indication	M	M
Conversion prohibition	O	O
Conversion prohibition in case of loss of information	M	M
Converted indication	M	M
Deferred delivery	M	M
Deferred delivery cancellation	O	O
Delivery notification	O	O
Delivery time stamp indication	O	O
Designation of recipient by directory name	M	M
Disclosure of other recipients	O	O
DL expansion history indication	O	O
DL expansion prohibition	O	O
Explicit conversion	M	M
Grade of delivery selection	M	M
Hold for delivery	M	M
Implicit conversion	M	M
Latest delivery designation	O	O
Message flow confidentiality	O	O
Message identification	O	O
Message origin authentication	M	M
Message security labelling	M	M
Message sequence integrity	O	O
Multi-destination delivery	M	M
Non-delivery notification	M	M
Non-repudiation of delivery	O	O
Non-repudiation of origin	M	M
Non-repudiation of submission	O	O
Original encoded information types indication	M	M
Originator requested alternate recipient	O	O
Prevention of non-delivery notification	O	O
Probe	O	O
Probe origin authentication	O	O
Proof of delivery	O	O
Proof of Submission	O	O
Redirection disallowed by originator	O	O
Redirection of incoming messages	O	O
Report origin authentication	O	O
Requested delivery method	O	O
Restricted delivery	M	M
Return of content	O	O
Secure access management		
Stored message alert	O	O
Stored message auto-forward	O	O
Stored message deletion	O	O
Stored message fetching	O	O
Stored message listing	O	O
Stored message summary	O	O
Submission time stamp indication	O	O
Use of distribution list	M	M
User/UA capabilities registration	M	M

M - Mandatory O - Optional

Table 3-6. Summary of COMFAX Services

Service	Short Term	Long Term
Abbreviated addressing†	M	M
Automatic reception	M	M
Broadcast†	M	M
Closed user group†	M	M
Database query	M	M
Database submission	O	O
Date, time, and originator's identity†	M	M
Deferred delivery by originator†	M	M
Deferred delivery by recipient	M	M
Delivery confirmation†	O	O
Hold for delivery requested by originator†	M	M
Hold for delivery requested by recipient†	M	M
Information retrieval	O	O
Multiaddress†	M	M
Multipage facility	M	M
Non-delivery advice†	M	M
Recall Attempts	M	M

† Similar services offered by MHS
M - Mandatory O - Optional

modifications and could be modeled after Telex's and Teletex's IPMS access procedures; it would permit existing equipments to take advantage of the IPMS. The long-term mechanism would allow protocol modifications and would provide an evolutionary path for additional capabilities. Both would stress compliance with existing standards while permitting capabilities as previously shown in Table 3-5 and Table 3-6.

3.4.3.1 Telex and Teletex-like Access Procedures for Group 4 Facsimile

In the short term, Group 4 could use IPMS access procedures that are similar to Telex and Teletex. Telex uses two approaches to access the IPMS.[7] The first approach permits Telex equipments to believe that they are communicating with another Telex equipment. In actuality, they are communicating with a IPMS UA designed especially for intercommunication with Telex. Typically, a IPMS user registers with the UA to receive telex messages, and is assigned a telex number by the UA. Any telex equipments calling that number will have their message received by the UA which assumes responsibility for delivering the message to the recipient.

In the second approach, the IPM service is made visible to the telex user with the UA acting as a gateway. Access to the UA is done using normal telex procedures (Stage 1 of 2). Then the user constructs a "special" telex message which consists of two parts: a header and a message body (Stage 2 of 2). The header contains IPM delivery instructions, while the message

body is what is to be delivered. Both the header and the message are then mapped by the UA into the IPMS's "envelope and message" format and handed to the IPMS. This approach has a major advantage over the first in that most of IPMS's services can be taken advantage of (like multiaddressing, deferred delivery, etc.).

Teletex access procedures are similar and appear to support only basic Teletex (No mixed-mode or processable form modes).[8],[9]

Group 4 fax could copy these access procedures. For simple deliveries, IPMS Group 4 recipient registration would permit Group 4 to access and use store-and-forward capabilities on a limited basis. For greater functionality, a two stage approach could be used. In stage 1, the Group 4 equipment would call a Group 4 fax AU using normal Group 4 access procedures. In stage 2, the Group 4 equipment would send the AU a cover sheet (T.6 encoded) containing delivery and reporting instructions followed by the encoded message. By using human-readable graphic characters (like those of Recommendation T.61), these instructions might be easily constructed using simple office equipments (typewriters, for instance), and by using T.6 encoding would standardize Group 4 to MHS access procedures (Class III equipments could potentially use T.61 character codes). Upon receipt, the AU would decompress and interpret the instructions using Optical Character Recognition (OCR) techniques and would ascertain the trailing message's true destination. Furthermore, the format of these instructions could, in general, follow the guidelines established by Recommendation T.330 (also followed by Telex and Teletex) which permit single or multiple O/R addresses, requested delivery methods, requested reports, etc.

A major difficulty facing the use of store-and-forward facilities by Group 4, however, is the fracture in the Group 4 protocols which prevent Class I equipments from communicating with either Class II or Class III equipments. A generic IPM Group 4 fax AU must address this issue if it is to reliably accept messages from all three classes. Doing so could be as simple as incorporating both protocol stacks into the AU while employing a mechanism to ascertain when each should be used.

3.4.3.2 Long-Term Approach

In the long-term, modifications could be made to the Group 4 protocol to simplify IPMS access. For instance, header information, in the form of T.61 character codes, could be transmitted directly from Group 4 equipments to AUs without requiring T.6-encoded cover sheets.

4.0 TERMINAL MODIFICATIONS

Fully exploiting COMFAX and IPMS capabilities efficiently may require modifying facsimile terminals, especially Group 3 terminals. For example, most existing fax terminals are ill-equipped to provide UAs and facsimile servers with destination addresses. Their protocols were designed specifically for fax-only communications and were not intended for use with other services like store-and-forward. Nevertheless, by making char _ s to their protocols they can efficiently interact with and use those services. These changes, given the difficulty of modifying existing equipments, are mainly likely to affect only future facsimile equipments. Nevertheless, existing fax equipments will also need a mechanism, however inefficient, if they are to also use COMFAX and IPM services. These dissimilar requirements suggest, as mentioned before, using two mechanisms: one short-term and one long-term. The short-term mechanism might connect existing equipments to IPMS. The long-term mechanism might permit protocol modifications and might provide pathways for future functionality. In addition, these mechanisms should, in general, conform to the short- and long-term requirements discussed in Section 3.4.2, "*Group 3 Fax Modifications.*"

4.1 Short-Term Mechanisms

A few potential short-term mechanisms are Dual-Tone MultiFrequency (DTMF) signaling, Optical Character Recognition (OCR) methodologies, and character-based transmissions.

4.1.1 DTMF Signaling

DTMF is a widespread signaling method accessible from most touch-tone telephones. It is capable of transporting commands and information to IPMS and COMFAX UAs, either

manually or automatically. (UAs, in this sense, also includes devices like facsimile gateways for local area networks, facsimile servers connected to voice and data switches, etc.) Consider the following use of DTMF in a store-and-forward session:

1. The originator's terminal dials an access number to connect to a facsimile gateway (or server).
2. The gateway authenticates the originator's terminal.
3. The originator's terminal sends the facsimile's destination addresses (or distribution lists) using DTMF commands.
4. The originator's terminal sends additional commands using DTMF.
5. The originator's terminal exits from command mode and enters transfer mode.
6. The originator's terminal transfers the facsimile message to the gateway using the existing protocols (T.30 for Group 3).

This simple example demonstrates how DTMF might connect fax terminals to UAs, either manually or automatically, and might transport commands and instructions. Furthermore, DTMF appears to meet Section 3.4.2's, "*Group 3 Fax Modifications*" short-term requirements. DTMF has several other advantages:

1. DTMF is compatible with the T.30 protocol (Group 3).
2. It can use the embedded base of Group 3 machines to originate a request or to receive a response, without modifying the machines.
3. DTMF is communicable over switched voice networks and is widely available.

Nevertheless, DTMF does have some disadvantages:

1. There are human factors limits on the length or complexity of the touch-tone dialogue.
2. Human operators may have difficulty verifying manually keyed instructions.
3. DTMF is unavailable on some networks.

4.1.2 Optical Character Recognition Methodologies

Another potential short-term mechanism is OCR methodologies. Graphics characters or special marks on a page might convey the necessary instructions and information to the UA for delivering the fax message. For example, each transmission might consist of a cover page and a message, where the cover page specifies to whom and how the UA should deliver the message (See Figure 4-1). Using human-readable graphics characters makes possible using office equipment (like typewriters) to construct the cover page. Second, organizing them according to existing standards (T.330, U.204, for example) may help reduce the requirement for new standards and reduce modifications to existing ones. OCR has several advantages:

1. OCR is compatible with existing protocols (both Group 3 and Group 4).
2. OCR can use the embedded base of Group 3 and Group 4 machines to originate a request or to receive a response, without modifying machines.
3. OCR is communicable over almost any network (PSTN, PSDN, ISDN, etc.).
4. OCR can transport complex instructions and detailed information.

Nevertheless, there are drawbacks:

1. The UA must have an OCR capability.
2. The UA must decode the cover page (T.4, T.6) before using OCR to recognize the characters.
3. The UA might misinterpret characters (and instructions).

4.1.3 Character Transmissions

Facsimile equipments might mimic Telex and Teletex equipments and send binary octet-based (or similar) characters to the UAs. Sending characters has several advantages:

1. Efficient transmission of complex instructions and detailed information.
2. Characters are communicable over almost any network.
3. Requires no special sophistication within the UA.

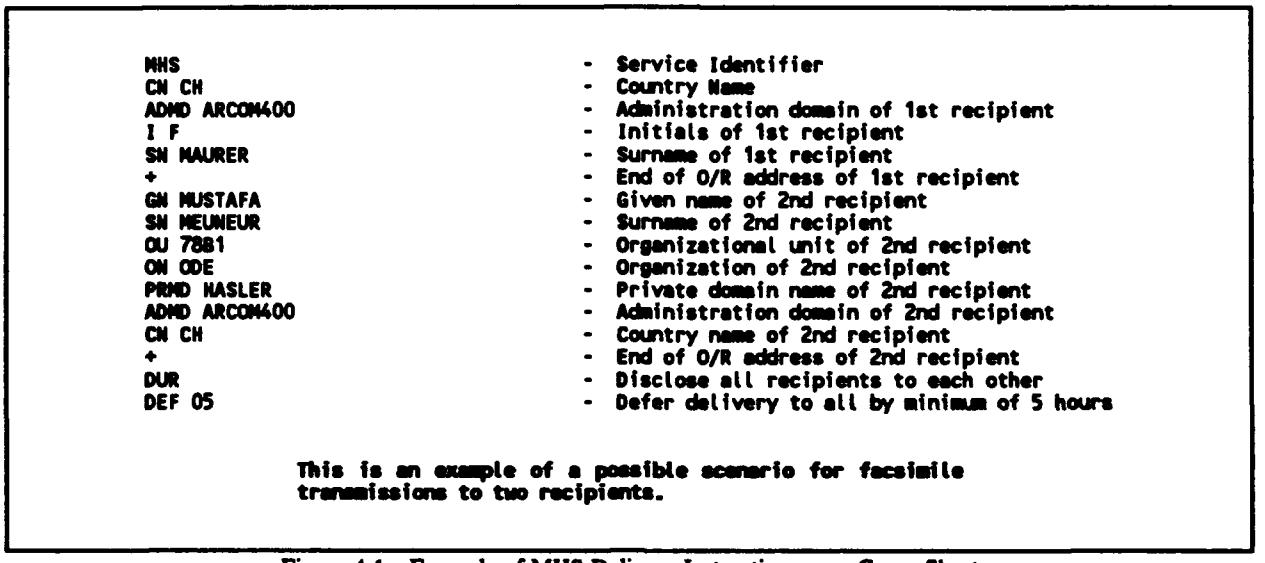

Figure 4-1. Example of MHS Delivery Instructions on a Cover Sheet

Unfortunately, character transmissions are currently incompatible with most existing Group 3 and Group 4 equipments. So, implementing might require modifying existing equipments. A possible exception is PC-based equipments. They are usually more easily upgraded, thanks to their expandability using plug-in cards or software upgrades or both. The CCITT is planning to add a character transfer mode capability to the Group 3 T.30 protocol.

4.1.4 Comparison

Since character transmissions require modifying existing terminals, the choices for a short-term mechanism are probably either DTMF or OCR. Each has its advantages and disadvantages (See Table 4-1). DTMF offers easy implementation, user friendliness, and widespread connectivity. OCR offers network independence coupled with full (or almost full) IPMS access for both Group 3 and Group 4 machines. Other considerations are that OCR's cover sheet lets human operators verify complex instructions prior to transmission. Whereas, DTMF's possibly cumbersome manual keying methodologies might limit the available suite of COMFAX and IPMS capabilities. Nevertheless, OCR does require considerable sophistication on the part of the UA.

Since neither has a clear advantage, permitting both might be a good solution. Especially if there is a desire to minimize UA complexity while also permitting full IPMS access over most networks for both Group 3 and Group 4 equipments. If both are used, DTMF could provide

Table 4-1. Comparison of Short-Term Mechanisms

Capability	Mechanism		
	MFPB	OCR	Character
Network Independent	no	yes	yes
Efficient coding of instructions	?	no	yes
Requires modifying terminals	no	no	yes
Easy implementation	yes	no	no
Requires complex UA	no	yes	no
Provides extensive MHS capabilities	possibly limited	yes	yes
Transmitted instructions verifiable	?	?	yes
User friendly (i.e., easy to use)	?	?	yes
Likelihood of instruction misinterpretations	low-medium	low-medium	low
Usable by Group 3 and Group 4	mainly Group 3	yes	yes

a limited set of COMFAX and IPMS capabilities over the PSTN, and OCR, as an option, could provide additional store-and-forward capabilities, extend store-and-forward to Group 4, and provide network independence.

4.2 Long Term Mechanisms

By making use of protocol modifications, long-term mechanisms are usually more efficient than short-term mechanisms. Furthermore, judicious modifications permit the long-term mechanisms to provide pathways for evolving capabilities while providing interoperability with existing equipments. To take full advantage of these modifications, fax equipment could elicit message transmittal information from the operator and electronically transmit it to the UA. At least three reasons suggest this approach: 1) to validate the information, 2) to reduce the chance of transmittal errors, and 3) to reduce UA complexity.

Mechanisms meeting these criteria are character transmissions and binary encoding. Binary encoding is similar to character transmissions, except it generally uses single binary bits to convey instructions or information that character transmissions carry in one or more octets.

Additionally, binary encoding is usually more efficient, although it does require a UA capable of understanding the encodings.

Two potential short-term mechanisms, DTMF and OCR, are, for several reasons, probably unusable as long-term mechanisms:

1) Validating information is either not possible or is cumbersome.
2) The likelihood of keying or reading errors increases the chance of misinterpreted instructions.
3) Inefficient methods for conveying instructions and commands.
4) For OCR, a great deal of complexity is necessary in the UA.
5) For DTMF, signaling system makes it network dependent.
6) Automating the method is either difficult or lacks elegance.

For the long-term mechanisms, the following events constitute a successful store-and-forward transfer:

1. The originator completes control information locally without connecting to a UA.
2. The originator's terminal connects to the UA.
3. The terminal transfers control information to the UA.
4. The UA accepts the facsimile message and assumes responsibility for its delivery.

4.3 Transition from Short-Term to Long-Term Mechanisms

For a brief period, during the transition from short-term to long-term mechanisms, UAs may have to support both. To ease this transition, some commonality between the two is probably desirable. Commonality may be possible if OCR provides the short-term mechanism and character transmissions provides the long-term mechanism. If the OCR instruction set is made a subset of the character transmission instruction set, transitioning from the short-term mechanism to the long-term mechanism might be as simple as bypassing the UA's character recognition module (See Figure 4-2).

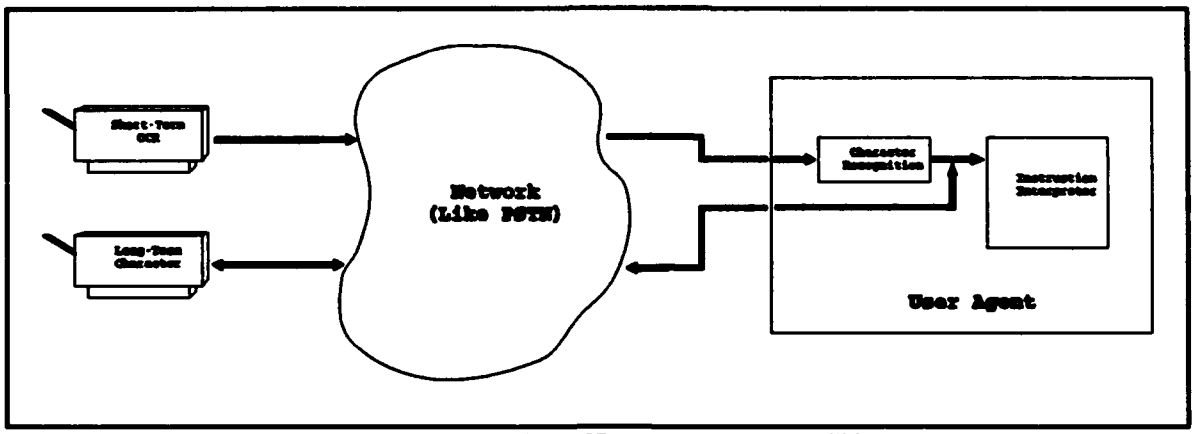

Figure 4-2. UA having OCR and Character Capabilities

If easing the transition from short-term to long-term mechanisms is not a concern, binary encoding may be preferred as the long-term mechanism. It is usually more efficient than character transmissions, and usually compacts more information into fewer bits. A comparison of these two mechanism is shown in Table 4-2.

Table 4-2. Comparison of Long-Term Mechanisms

Capability	Binary Encoding	Character
Network Independent	yes	yes
Efficient coding of instructions	yes	yes
Requires modifying terminals	yes	yes
Easy implementation	no	no
Requires complex UA	no	no
Provides extensive MHS capabilities	yes	yes
Transmitted instructions verifiable	yes	yes
User friendly (i.e., easy to use)	yes	yes
Likelihood of instruction misinterpretations	very low	low
Usable by Group 3 and Group 4	yes	yes
Compatibility with one or more short-term mechanisms	low	high

5.0 CONVERSION RULES

At present, the CCITT has a recommendation (X.408), primarily for MHS, for the specific purpose of performing conversions between different types of encoded information. Although the recommendation contains a large number of possible conversion permutations, it does not yet have permutations for Group 4 Class 2 and Class 3 equipments. Secondly, none of the defined *facsimile* permutations specify the conversion method(s) to use.

Group 3 (T.4) to Group 4 (T.6), Group 4 to Group 3, character to facsimile (e.g., PC to fax), and facsimile to character (e.g., fax to PC)[1] conversions should consider the following items:

- Pel or pixel resolutions
- Document colors (Black and white, continuous tone gray scale, color, and halftone images)
- Established and future encoding methods
- Transmission rate differences

Conversion rules that consider the above items could build on ongoing work by JBIG and JPEG. Both JBIG's and JPEG's algorithms are designed to support a wide range of applications.

5.1 Image Resolution Conversion

Of particular importance to any conversion algorithm is its ability to convert an image from one resolution to another. Both JBIG's and JPEG's algorithms incorporate the ability to perform resolution conversions. They are able to progressively "buildup" or make a higher resolution image based upon an initially "rough" or low resolution image, and to tear-down or make low resolution images from high resolution images. Furthermore, their techniques for preserving edges, lines, dither patterns, and periodic patterns is probably useful to other conversion techniques for converting images from higher to lower resolutions, or vice versa, and

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1. A standard for converting fax to characters may become desirable as demand for the capability grows.

from one image color to another (Multilevel color to multilevel monochrome, etc.). Assuming JBIG's algorithms are acceptable, one potential candidate is the "PRES" algorithm.

The "PRES" algorithm performs "rough" image reductions, and realizes resolution reductions by 2:1 in both the horizontal and vertical dimensions while preserving fine lines, gray scales, periodic patterns, etc. It does this by using a difference equation as a reduction rule.

The reduction rule uses pel values, 1, 0 (black, white), from both the original image and the reduced image to determine the reduced image's pel values. The original image is viewed through a 3 by 3 pel window which moves from left to right and from top to bottom; where the reduced pel being determined corresponds to the four pels in the lower, right-hand corner of the window (See Figure 5-1). Within the reduced image, the pel being determined belongs to a 4 by 4 pel window, where it is the lower, right-hand corner pel. The values of the other three pels and all the pels in the 3 by 3 pel window determine the value of the reduced pel. Altogether, twelve pels play a role, and in general, if more than half of the pels are black, the pel being determined will be made black.

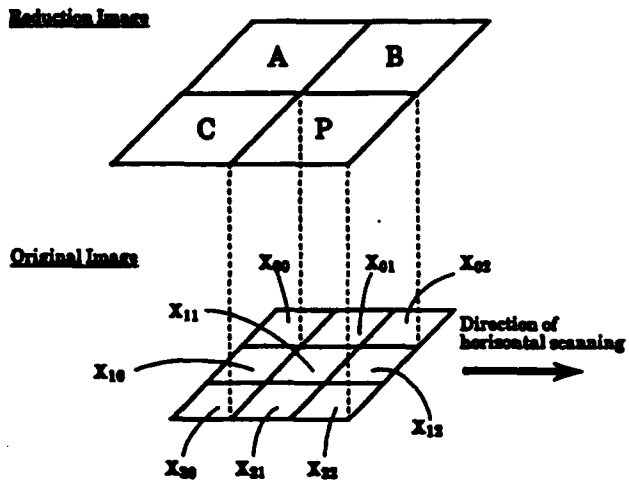

Figure 5-1. Relationship between Original and Reduced Images

Because this filtering process destroys detail (fine lines, periodic patterns, etc), preserving detail is achieved by exceptions to the reduction rule. The basic concept of exception is to preserve one pel width line elements when specific pel patterns are found in the 4 by 4 and 3 by 3 windows. Whenever an exception is encountered, a predefined pel value is used.

There are four types of exceptions:

- o Edge preservation
- o Line preservation
- o Periodic pattern preservation
- o Dither pattern preservation

These exceptions significantly improve the reduction image quality and thereby have priority over the reduction rule. Nevertheless, not all the exceptions are symmetric between positive and negative patterns. Preserving a one pel width black line contradicts preserving a one pel width white line when they are adjacent. So, when such trade-offs exist, the positive patterns are given priority, i.e., the one pel width black line. Symmetry in the X and Y directions is kept for almost all exception patterns.

Modifying the PRES algorithm to handle resolution conversions other than 2:1, like 3:2 (300 to 200 pels/inch), is a possibility. The modifications might use a scaling algorithm to tailor both the PRES algorithm and its exceptions to the desired resolution. Or, for a standard set of conversions, they might use predetermined exception patterns and algorithm matrices. For the latter, a "best-fit" approach could resolve any unusual conversions.

5.2 Document Color Conversion

Besides resolution, conversion algorithms should probably also consider the colors and tonal range of a document. Converting from one type of image to another can severely distort an image if done carelessly. For example, using a fixed-threshold for converting color photographs to bi-level black and white is likely to severely distort the original image.

5.2.1 Image Types

Faxable images tend to fall into three categories: continuous tone, halftone, or line copy.

5.2.1.1 Continuous Tone Monochrome and Color

Continuous tone monochrome and color, contain an apparent continuum of gray levels. Moreover, some scenes, when viewed by humans, may require more than 256 discrete gray levels to give the appearance of a continuum of gray levels. Continuous tone is exemplified by television images, photographic images, and real-world scenes. Therefore, it is composed of "natural" images and their approximations.

5.2.1.2 Halftones

Halftone imagery was developed in the mid-19th century as a technique for approximating the continuum of gray scales available in "natural imagery." This process uses high frequency line and dot structures, whose width vary spatially throughout a scene, to yield a varying reflectance across a page. The end result is that when the page is viewed at normal viewing distances (about 14 inches) the line or dot structures are unnoticeable, but the varying average gray level produces an approximation to the natural scene. All mass printed media, magazines, books, etc., use halftone technologies.

5.2.1.3 Line Copy

Line copy imagery consists of alphanumeric characters, straight line segments, and solid areas of a single gray area. The image is made up of just two grey levels; but, unlike halftones, only lines, etc., of visible size are created. Except for their halftone images, books, magazines, etc., are two-tone line copy. Making indistinguishable (or nearly so) facsimiles of these image types, and their mixtures (pictorial magazines,etc.) depends on available scanning, printing, image conversion, image transmission, and image compression technologies.

5.2.2 Color to Continuous Tone Monochrome

For a document's color gamut, there are two main considerations: the number of colors present (or the fewest number of colors (primaries) which can represent the document's color gamut), and their intensity or luminosity. For example, for a black and white document there

is just one color - black, and there are two color intensities - on or off. For gray scale, there is also just one color (black again), but a continuum of intensities. For color documents, a similar situation applies, except there are many colors.

Color documents are viewable in monochrome at the expense of the vibrancy of color, i.e., the colors appear as different shades of gray. For instance, black is grayer than blue, blue is grayer than red, red is grayer than yellow, and yellow is grayer than white. Considerable research has been done on color, and color researchers have developed a color representation scheme which allows all colors to be represented by three constituent components.[10] Two indicate the color without intensity (chroma), while the third represents just the color's intensity (luminosity). This scheme is known as the XYZ color space. Its advantage is that the luminous component (Y) also provides a color's monochrome gray scale value, and is usable for converting color documents to monochrome.

5.2.3 Continuous Tone Monochrome to Bi-Level Monochrome

Similarly, gray scale is viewable in a bi-level form, although the information loss is usually greater than that lost when viewing monochrome versions of color documents. Bi-level or binary representations of gray scale documents (and color) dates back to the 8th century, and includes relief printing (letter press), intaglio (gravure), and lithography. In general, these processes generate two-tone microstructures composed of regions with or without ink. Today, almost all printed pictorials are composed of "binary" microstructure. Even full color pictorials (in magazines, etc.) are composed of four inks operating in a binary mode.

5.2.4 Monochrome and Color Conversion Techniques

There are several methods available to convert an image from one image type to another while respecting the resolving capabilities of the various facsimile printing technologies. As noted before, gray scale images can be accurately reproduced using halftone images. Unfortunately, current facsimile printers (binary with ~200 pels per inch resolution for Group 3) are usually unable to provide the resolution needed to reproduce such halftones. Nevertheless, halftones and other methods can provide facsimiles which "roughly" approximate

the original. They may have just a fraction of the original document's gray scale continuum; but, distortion can be minimized to provide a "reasonable" facsimile of the original.

These methods or techniques include globally fixed level thresholding, locally adaptive thresholding, orthographic tone scale creation, electronic screening, pseudorandom thresholding or ordered dither, and error diffusion.[11] These methods differ in their ability to accurately represent gray scale levels and halftones. Nevertheless, the best methods for gray scale or halftones are possibly inadequate for line copy. So, besides accurately reproducing gray scales, a method suitable for facsimile reproduction should also maintain fine detail (line edges). Finally, the "rough" facsimile approximations will, in general, have artifacts in them that result from the processing method. Artifacts fall into three categories: false detail (moiré), false contour, and false textural contour.

False detail is usually the "beating" of two relatively high frequency processes whose resulting spatial frequency signal is low enough to be seen.

False contours are a result of gray scale quantization steps which are sufficiently large to create a visible contour when the original image is really a smooth, gradual variation from one to the other.

False textural contours is similar to false contours; but, is caused by artificial changes in the image texture. Because the print process is binary, and gray scale information must be encoded via a pattern over some area which results in an average percent reflectance equivalent to a desired gray level, different textures can be used for different gray levels. When the input gray levels vary slowly, the output will generate an artificial boundary between the textural patterns for one gray level and the textural patterns for the next gray level.

5.2.4.1 Globally Fixed Thresholding

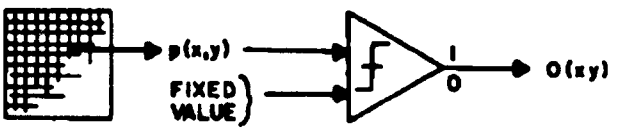

Figure 5-2. GFT Processing

Globally Fixed Level Thresholding (GFLT) compares a gray level against a constant (See Figure 5-2). If the gray level is above the value, then the result is assumed to be white. Otherwise, it is black (See Figure 5-3). This method has a very limited tone scale reproduction capability; the two ends

of the gray scale are reproduced accurately, but the remainder is severely distorted (good for text, but poor for gray scale). GFT is how most of today's facsimile equipments, especially Group 3, process input images.

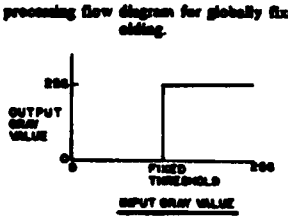

Figure 5-3. GFT Function

5.2.4.2 Locally Adaptive Thresholding

Locally Adaptive Thresholding (LAT) is an extension of GFLT, and there are two main strategies: line copy adaptive thresholding (LCAT), and constrained average thresholding (CAT). LCAT is directed specifically towards facsimile and OCR applications with the intention of optimizing the process for line copy imagery as opposed to pictorial input. CAT, on the other hand, attempts to provide extended tone scale range so continuous tone information is reproducible.

LCATs generally have one or two technical strategies behind them. The first strategy is to detect edges within the input image. Once an edge is detected, the predominant strategy is to update the value of the threshold to be some arithmetic function of edge pixels. The second strategy uses a memory of observed gray levels within the image to estimate the distribution of white to black picture elements within the image. Once known, a computation is performed to estimate the desired threshold level which will discriminate the line detail. The primary purpose of these methods is to provide high quality line copy while suppressing gray scale.

CATs attempt to incorporate gray scale information. In general, they compute a local average. For instance, one approach uses the linear sum of all the pixels in a 3 x 3 array and uses it to calculate the threshold for the central pixel. This approach is good for approximating gray scale reproduction; but, artifacts are present, and line copy edges are blurred. Also, the overall appearance of images reproduced with this method are usually more spatially nonuniform and "dirtier" than algorithms with regular structure.

5.2.4.3 Orthographic Tone Scale Creation

Orthographic Tone Scale Creation (OTSC) uses "*n* x *n*" pixel arrays in the form of gray scale "characters" to represent pictorial imagery (See Figure 5-4). These characters together

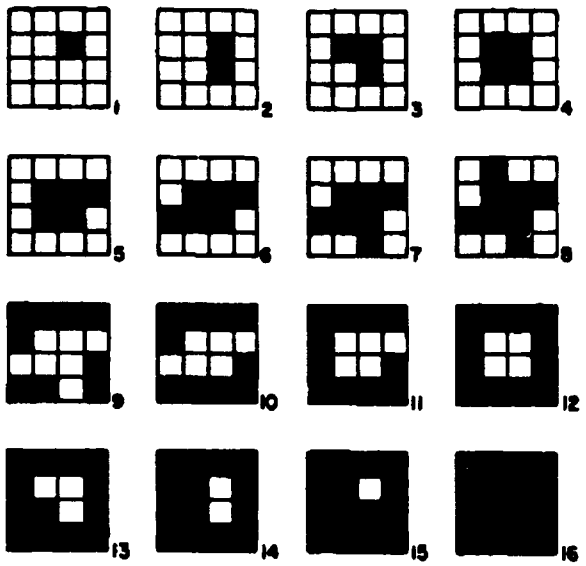

Figure 5-4. Example of Orthographic Fonts

form a gray scale font which, when printed with minimal intercharacter spacing, can yield reproductions of pictorial information. Ideally, the assumption is that the output rate is high enough to allow an output pixel array to represent each sampled input pixel. Unfortunately, this is not always possible and usually results in relatively coarse output tone scales. Secondly, the coarseness of the tone scales invariably result in false contours, and, depending on the chosen font, dramatic textural contours. Also, depending on the coarseness of the pixel arrays, the "characters" themselves may be visible.

5.2.4.4 Electronic Screening (Halftones)

Electronic Screening (ES or Halftones) is an extension of photomechanical screening which was developed in the mid-19th century (See Figure 5-5). Input pixels are compared with a single threshold selected from a two-dimensional matrix, and a black or white decision is made. The thresholds are selected in sequential order, and the set of thresholds and their arrangement within the matrix determine the gray scale range, frequency, angle, and other halftone properties. When the matrix (or unit cell) is repeated horizontally and vertically, it creates the entire screen function. Unlike OTSC, ES is capable of detail rendition at

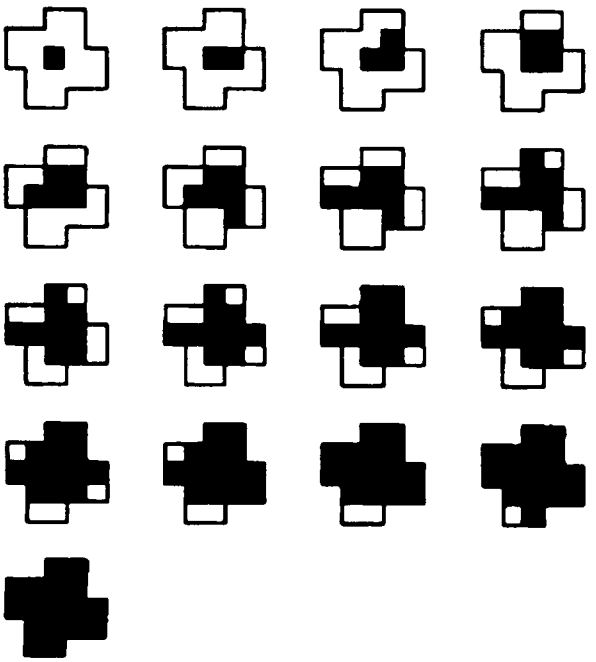

Figure 5-5. Halftone Representation Using Pixels

pixel resolutions, and is capable of generating a complete tone scale. ES can be viewed as providing the best high frequency capabilities (equivalent to fixed thresholding) for high contrast input, and gradually less detail rendition capability for lower contrast input, with the limit being a capability of reproducing the smallest of gray scale detail at the cell frequency. The primary artifact generated is the high frequency dot pattern. For normal viewing distances, a dot frequency of 100 cells/inch or higher results in a relatively invisible artifact to the human eye. This requires a print resolution of at least 400 pixels/inch (Group 4 allows 400 pixels/inch). Below 85 cells/inch (print resolution of 340 pixels/inch), the cell, false contours, and textural contours become visible.

5.2.4.5 Pseudorandom Thresholding or Ordered

Dither Pseudorandom Thresholding or Ordered Dither is a technique for minimizing the number of gray levels required to manifest acceptable pictorial imagery. In general, dither adds a two-dimensional pseudo-noise sequence to an input image prior to quantization to two gray levels (Black or white). The end result is that the spatial distribution of errors allows an observer to visually integrate the average percent reflectance in a small region, and, therefore, "see" a near continuum of grey levels (See Figure 5-6). This process is, in essence, another form of ES; except, dithering results in a dispersed set of dots instead of a single "dot". Because of the dispersal, visible frequency components resulting from the pseudorandom thresholding (textural contours) may be seen, depending on the input gray levels. To eliminate false contours, matrices with roughly 64 distinct thresholds are usually used (See Figure 5-7).

Figure 5-6. PseudoRandom Thresholding

0	16	4	20	1	17	5	21
24	8	28	12	25	9	29	13
6	22	2	18	7	23	3	19
30	14	26	10	31	15	27	11
1	17	5	21	0	16	4	20
25	9	29	13	24	8	28	12
7	23	3	19	6	22	2	18
31	15	27	11	30	14	26	10

Figure 5-7. Matrix to Reduce Contours

5.2.4.6 Error Diffusion

Error Diffusion, like Ordered Dithering, takes advantage of the viewer's spatial integration capabilities. It provides high quality pictorials by direct spatial distribution of the

errors created by coarse gray scale quantization. Usually, the error between the gray level (black or white) used to print a pixel and the value of the input pixel at that location is dispersed among the neighboring pixels to the right and below the pixel being processed. When these neighboring pixels are quantized, the errors will be corrected, with the errors going to zero over distances which are a function of the weighted distribution of the errors as well as the values of the input image.

5.2.4.7 Applicability to Halftones

These methods, although fine for converting continuous tone images, meet with less success when converting halftones. In general, the frequencies of the halftones and those of the conversion algorithm tend to "beat," resulting in visible moiré patterns. One way to prevent such patterns, is to preprocess input images into "continuous tone" images prior to converting them. For instance, it is possible to process a halftone such that the halftone frequencies are either reduced or eliminated, although at a risk of loosing low contrast detail. This approach does permit, however, the processing of continuous tones and halftones by the same conversion algorithm.

5.3 Encoded Document Conversions

At present, a number of vendors offer integrated circuits that can easily convert documents from a T.4 to T.6 encoding, and vice versa. Other vendors use software techniques. To convert a document, these vendors usually simply decode the document and then recode it. Typically, these conversions are for Group 3 to Group 4, and vice versa, document conversions. Performing these conversions has been simplified now that Group 3 has the *option* of using T.6 coding methodologies. When used, no conversion is necessary.

While conversions are occurring between Group 3 and Group 4, it may be necessary to consider the difference in transmission rates between the two. For instance, Group 4 can transmit at 64 kb/s versus Group 3's maximum rate of 14.4 kb/s. Fortunately, MHSs usually perform automatic rate adaption. Where they don't, the faster of the two should probably match the slower's speed. Registered terminal capabilities should probably include transmission rate capabilities to allow this function.

5.3.1 Facsimile to Text

The conversion of fax to text, e.g., for fax to PCs or Telex, may eventually become desirable. Automatically transforming text-based facsimiles to character documents requires an OCR capability. Text comes in many forms, both machine-made and handwritten. For example, there are hundreds of type fonts and thousands of print fonts in the world, and each has its own distinctive style and peculiarities.[12] (Styles and peculiarities include items like serifs, shapes, curvatures, sizes, pitch, line thickness, and so forth.) Variations in handwritten characters are even greater. Each person has his own way and style of writing and samples from the same hand are seldom identical in shape or size. The most confusing character pairs, especially when written sloppily, are 6/G, D/O, I/1, S/5, 2/Z, and U/V. This is mainly because they have very similar topological structures.

An OCR system is shown in Figure 5-8. At the input end, the OCR locates the regions where data has been printed or written and segments them into character images. After segmentation, a preprocessor then eliminates random noise, voids, bumps, and other spurious

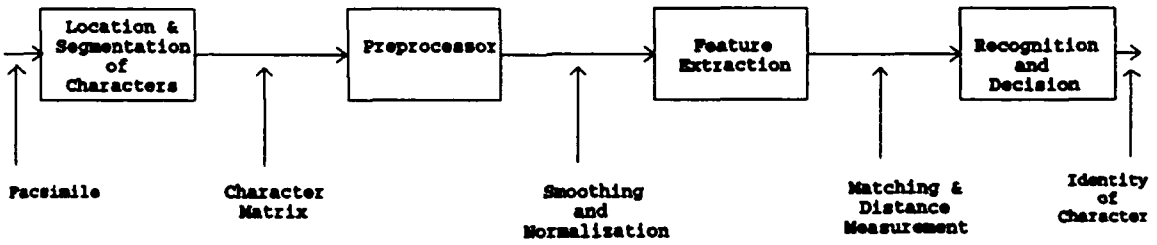

Figure 5-8. Example of an OCR System

components of the segmented characters, if present, and thins the characters. This process is known as smoothing. Sometimes, normalization in size, orientation, position, and other operations are done to help the following stage extract distinctive features. Normalization produces patterns of uniform size or linewidth, fixed boundaries along certain edges (top-left justification), or a preferred orientation (vertical). Doing so usually simplifies feature extraction and improves the recognition rate. After the image is smoothed and normalized, the feature extraction stage extracts the features which allow the system to discriminate correctly one class of characters from others. After the features are extracted, the recognition and decision stage classifies them by comparing them to a list of references and knowledge base. This stage also

uses distance measurements, shape derivation, shape matching, and hierarchical feature matching in the form of decision trees. The decision stage is strongly influenced by the extracted features, and a successful OCR is built on the joint operations and performances of the feature detector and the classifier.

The conversion of fax to text should consider facsimiles containing graphics figures. For example, an MHS with OCR capability could, when it encounters non-text, leave the non-text as graphics and reconstruct the document as a mixed-mode document according to ODA rules. Or, it could use superimposed text characters to approximate the graphical images. For the latter, the facsimile is then printable on most simple character-oriented hardcopy terminals.

5.3.2 Text to Facsimile

Converting from text to facsimile is a relatively easier process. This capability is already provide by most store-and-forward facsimile services (e.g., AT&T and MCI). They permit PCs to access their systems and send character-based messages to facsimile terminals. The service assumes responsibility for converting the character-based messages to facsimiles suitable for delivery. In essence, a bit-mapped, faxable version of the text document is made. For example, a number of commercially available PC products are already able to convert output files from popular wordprocessors (Wordperfect, Wordstar, etc.) to fax transmittable binary files. These products account for features like fonts, size, pitch, kerning, etc., and in some cases permit the inclusion of graphical imagery. MHSs could follow this lead and provide similar services.

6.0 RECOMMENDATIONS

Providing store-and-forward capabilities to existing and future Group 3 and Group 4 terminal equipments is possible. For existing terminals, no modifications are necessary. For future terminals, modifications are recommended if efficient services are desirable. Providing these capabilities should probably use compatible short-term and long-term mechanisms with the following characteristics:

Short-term

1. Register terminal capabilities with store-and-forward systems (Group 3 only).
2. Use single stage and two-stage procedures for accessing and using store-and-forward capabilities. The single stage procedure uses addresses in the accessing network's address space for registered equipments. Equipments calling those addresses will have their messages sent to the registered terminal. The two-stage procedure uses a first stage to access the store-and-forward, and the second stage uses MTBF (Group 3) or a cover page and OCR (optional for Group 3, mandatory for Group 4) to specify store-and-forward instructions and distributions.
3. For Group 3, have store-and-forward perform poll operations.

Long-term

1. Use Character transmissions. It provides compatibility with the short-term mechanism.
2. Instruction set should be super-set of the short-term mechanism's instruction set.

Using OCR in the short-term mechanism also possibly provides the store-and-forward system with the capability of performing text-based facsimile to character document conversions. For bi-level imagery resolution conversions, possibly use a scaled version of JBIG's PRED algorithm.

This approach assumes compatibility between existing terminals and future terminals coupled with extensive store-and-forward capabilities for both is a desired goal. Thus it stresses interoperability between future and existing terminals by using compatible procedures (OCR and Character transmissions) and making the future terminals' store-and-forward instruction set a super-set of the one for existing terminals. Also, although OCR requires considerable sophistication in a store-and-forward system, if present, it might also provide a mechanism for converting facsimiles to character-based documents for recipients who can only receive such documents. Making future equipments use characters instead of binary encodings does reduce efficiency, but does simplify and ease the transition from existing to future equipments by preserving the store-and-forward instruction stream.

If the U.S. government takes advantage of store-and-forward services, it can realize several benefits. Most importantly, the realization of improved productivity and lower costs. Electronic mail is usually faster than the physical mail services. It reduces the communications cycle, and by doing so compresses delays associated with document deliveries, possibly shorting the duration of a particular task. Second, the sender may receive confirmation that a delivery occurred and that the recipient received the message. Confirmation that a recipient received a message might be triggered by the recipient's viewing the document with a fax viewing software package. With fax to fax transmissions over the PSTN, there is no guarantee that the message was delivered to the recipient nor that he received it. Conversely, if the message is undeliverable, the sender may also receive a non-delivery notification. This allows the sender to take appropriate action (e.g., resubmit the message). Third, the ability to send a single message to many recipients. The message is sent once, freeing the sender's terminal for sending or receiving other communications. Lists of recipients may be registered with the MHS. The lists are usually easily modified to add or delete recipients. Plus, these lists may usually be combined with ad hoc recipients. Fourth, messages may be encoded to ensure message confidentiality. This helps to ensure that eavesdroppers are denied access to sensitive or private information. Fifth, message deliveries may be deferred. A sender might do this to take advantage of off-peak hourly rates, especially if he sends to a large number of recipients. Sixth, if the MHS has message store capabilities, messages may be sent to recipients even if their terminals are busy or off-line. The recipients may retrieve their messages from the message store at a later time assuming they provide proper authentication (e.g., passwords). This capability assures a sender that his message was delivered and when the recipient retrieves the message a receipt confirmation assures the sender that the message was received. The sender need take no action unless the recipient fails to retrieve the message (e.g., let the recipient know

there is a message). Finally, some MHSs offer automatic retry of message delivery if the recipient's terminal is busy or off-line. The sender is usually unaware of the retrys unless they fail or if he requests an exception report. Exception reports usually indicate total number of messages delivered, those pending, and those that were undeliverable. After receiving such a report the sender may take appropriate action, e.g., cancel the transmission, resend the message to some recipients.

7.0 AREAS FOR FUTURE STUDY

The following are some possible areas for future study.

- Assess the effectiveness, reliability, and speed of OCR as a mechanism for interpreting store-and-forward instructions from a facsimile terminal.
- Perform a subjective study on keying errors and limits on the length of manually keyed instructions for DTMF. Compare to keying and interpretation errors for OCR. Perform subjective comparison of user-friendliness of both.
- Assess the effectiveness, reliability, and speed of OCR as a mechanism for converting facsimiles to character-based documents, identifying graphics only areas, and simulating graphics with characters.
- Assess the performance differences between the character and binary encoded methods for transporting instruction streams from facsimile terminals to store-and-forward systems, and vice versa.
- Study scaling mechanisms for JBIG and JPEG resolution conversion algorithms.
- Investigate methods for regenerating continuous tone images from halftones, evaluate their rendition accuracy, and evaluate their effectiveness at reducing "beat" patterns resulting from conversion to bi-level imagery.

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